



RESEARCH DEPARTMENT

The Artificial Reverberation Test Set

Report No. C-087

(1955/5)

**THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION**

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Section	Title	Page
1	INTRODUCTION	1
2	DESCRIPTION OF APPARATUS	1
	2.1. General	1
	2.2. The Cathode Ray Tube	2
	2.3. The Time Base	2
	2.4. The Logarithmic Y Amplifier	2
	2.5. Power Supplies	5
3	CALIBRATION OF THE TEST SET	5
4	USE WITH THE ARTIFICIAL REVERBERATION MACHINE	6
	4.1. Measurement of Reverberation Times	6
	4.2. Measurement of Noise	6
	4.3. Checking Erasure Efficiency	7
	4.4. Checking the Nominal Frequency Response	7
5	REFERENCES	7

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1. INTRODUCTION.

Report No. A-036 on "Artificial Reverberation" included a description of the artificial reverberation machines now being used in the Television and Sound Services. Hitherto the adjustment and maintenance of this equipment has been the responsibility of Research Department. With the introduction into service of further machines, manufactured by Equipment Department, the normal Corporation machinery of installation and maintenance is to be brought into effect. The initial calibration of reverberation time on each machine, and other maintenance tasks which may be necessary from time to time, require the use of acoustic measuring apparatus of special design. Acoustic measuring apparatus¹ developed in this Department for research purposes is suitable for the task and has been used, hitherto. However, this comprehensive apparatus contains many facilities which are unnecessary when used with the artificial reverberation machine and a general issue of it for this purpose alone would be quite unjustified. A smaller piece of test equipment has, therefore, been developed for use with the artificial reverberation machine. This Test Set enables setting-up and routine maintenance operations to be carried out on the artificial reverberation machine in conjunction with other normal test equipment held in operating premises. Since the Test Set is designed only to meet the requirements of the artificial reverberation machine it has been possible to make it small in size and fairly simple to use. The Test Set is a secondary-standard equipment which must be calibrated before being put into service. The calibration is effected by means of a mechanical decay calibrator provided for the purpose. One decay calibrator held in some central establishment will serve for the periodic calibration of any number of Test Sets.

2. DESCRIPTION OF APPARATUS.

2.1. General.

The Test Set is designed to check the following properties of the artificial reverberation machine:

- (a) Specified reverberation times.
- (b) Noise level.
- (c) Erasure efficiency in the delay unit.
- (d) Nominal frequency response.

The Test Set is contained within a small carrying case and two views of it are shown in Figs. 1 and 2. The indicating system consists of a 2 $\frac{1}{4}$ in. cathode ray tube of the long after-glow type. The complete circuit diagram of the equipment is shown in Fig. 3, and it includes the following units:

- (1) The cathode ray tube and its associated control circuits.
- (2) A single sweep time base.
- (3) A logarithmic Y amplifier.
- (4) Power supplies.

2.2. The Cathode Ray Tube.

The controls for the cathode ray tube are grouped on the front panel of the Test Set and comprise the following:

- (i) Brilliance.
- (ii) Focus.
- (iii) X and Y shifts.

The X shift is obtained by an alteration in the static operating conditions of V6 by means of R.37 and the Y shift is obtained by an alteration in the static operating condition of V8B by R.18. The potentials needed for these changes are obtained from a negative rail as described in Section 2.5.

2.3. The Time Base.

The decay characteristic of the artificial reverberation machine is observed, when the Test Set is connected, by injecting a tone into the apparatus, cutting the tone and at the same instant triggering the trace of the cathode ray tube to begin a single horizontal sweep. The second two operations are accomplished automatically by depressing a "Trigger" switch on the Test Set. The decaying, or reverberant, output of the machine, after the tone has ceased, is then observed directly as a decreasing Y deflection of the trace. The long after-glow property of the tube enables the whole decay pattern to be observed. The decay may be observed again by lifting the "Trigger" switch, which restores the input tone, and then depressing it once more. The single-sweep time base is of the Miller Integrator type and is provided by valves V4, V5 and V6 and their associated circuits. The action of the circuit has been explained in detail elsewhere^{2, 3}.

This particular design has been chosen because it maintains its sweep speed reasonably accurately, without adjustment, over a long period. In the present apparatus the length of the trace is adjusted by variation of R.23 and the length of time taken to traverse the screen by variation of R.27. The initial setting of the time base speed is carried out using a mechanical decay calibrator recently developed in the Acoustics Section of Research Department.

2.4. The Logarithmic Y Amplifier.

The correct output of the artificial reverberation machine after the input signal ceases is an alternating signal, the amplitude of which decays exponentially.

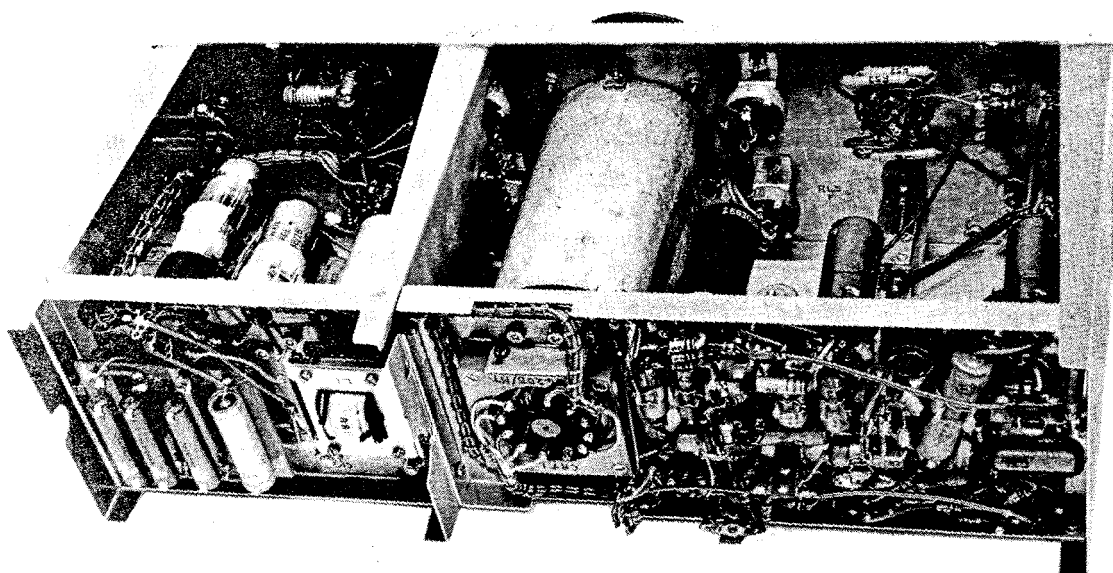


Fig. 1 - Internal View of Test Set

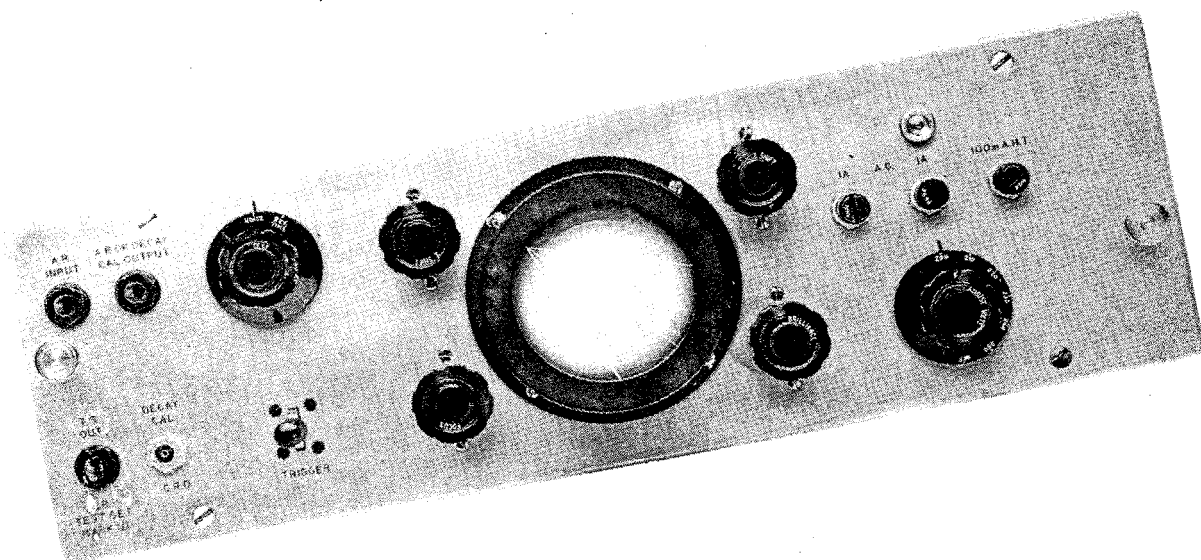


Fig. 2 - External View of Test Set

200/250V.
A.C.
50 c/s.

The rate of exponential decay depends on the reverberation time setting. It is not easy to carry out measurements upon an exponential decay displayed directly. Therefore, the Y amplifier of the Test Set is designed to give a D.C. output proportional to the logarithm of the amplitude of the incoming alternating signal. This means that an exponential decay from the artificial reverberation machine will be displayed as a straight line decay, the slope of which is easily checked. The logarithmic amplifier used in the Test Set is a simplified version of that described in Research Report B-056. One important difference is the employment of half-wave rectification of the logarithmic signal in place of the usual full-wave rectification. Some loss of detailed information in the decay occurs with half-wave rectification but since the purpose of the instrument is to measure only the mean slope of the decay, the resulting economy is fully justified. The output from the half-wave rectifier MR1 is fed, without further amplification, to the grid of a push-pull stage. This push-pull stage contains a double triode, 12AX7, that can be operated with a high anode load ($220\text{ k}\Omega$) and has a small standing anode current under zero bias conditions. By this means a high degree of linearity is achieved.

2.5. Power Supplies.

A conventional thermionic full-wave rectifier provides the low voltage supplies for the time base and logarithmic amplifier, while the high negative potential required for the time-base suppressor grid is provided by a selenium half-wave rectifier. The negative potential available is also used to alter the static operating conditions of V6 and V3B, as mentioned in Section 2.2. The E.H.T. supply for the cathode ray tube is obtained by means of a voltage-doubling circuit fed from the centre-tapped secondary winding that supplies the low voltage rectifier, thus eliminating the need for a separate E.H.T. winding on the mains transformer. The voltage doubler is a modified version of the Cockcroft-Walton circuit used in the production of very high voltages.

3. CALIBRATION OF THE TEST SET.

The initial adjustment of the time base speed and the linearity of the logarithmic amplifier in the Test Set is checked by means of the mechanical Decay Calibrator. This calibrator, the circuit diagram of which is shown in Fig. 4, consists of a series of ten calibrated attenuators increasing in value from 5 to 50 dB in 5 dB steps. Each attenuator is selected in turn by means of a uniselector switch driven by a synchronous motor through a variable speed gear box. The time taken for the switch to pass through all the attenuation positions and, in so doing, to attenuate the input to the Test Set in increasing amounts up to 50 dB, corresponds to the exponentially decaying input which would be provided by a perfect enclosure with the stated reverberation time. The method by which the calibration is achieved is then as follows:

- (a) Connect the output of a tone source (zero level, 1000 c/s) to the jack marked "T.S. Out" on the Decay Calibrator.
- (b) Connect the jack marked "Cal. 600 Out" on the Decay Calibrator to the jack marked "A.R. or Decay Cal. Output" on the Test Set.
- (c) Connect the socket marked "CRO Trig" on the Decay Calibrator to the socket marked

"Decay Cal. CRO" on the Test Set. The purpose of this connection is to trigger the time base in the Test Set simultaneously with the start of the decay signal from the Calibrator. A repetitive decay cycle, corresponding to a decay time of 1.8 sec, should then be observed on the cathode ray tube of the Test Set.

- (d) The potentiometers R.5 and R.27 in the Test Set are then adjusted until the slope of the decay displayed on the cathode ray tube conforms to the relevant engraved line (marked "1.8") on the graticule.

4. USE WITH THE ARTIFICIAL REVERBERATION MACHINE.

4.1. Measurement of Reverberation Times.

For this measurement the "Test" switch on the Test Set is set to "Rev. Time", the "Rev. Time" switch on the Delay Unit panel of the artificial reverberation machine is set to correspond to the "1.8" reverberation time marked on the graticule of the Test Set oscilloscope, and the "Repro. Head Mon." switch at the back of the Delay Unit is set to the position marked "Rev. Out". The input of the artificial reverberation machine is connected to the jack marked "A.R. Input" on the Test Set and the output of the artificial reverberation machine is connected to the jack marked "A.R. or Decay Cal. Output" on the Test Set. A tone source output at zero level is then connected to the jack marked "T.S." and with the "Trigger" key in the centre position, the tone will be fed continuously to the artificial reverberation machine. The frequency response of the machine when fed with a series of steady tones is, like that of a studio, not smooth, but shows of a series of maxima and minima. In addition to this the mean frequency response of the apparatus is arranged to fall off at higher audio frequencies to simulate another common property of studios. It is, therefore, desirable to check the reverberation time at several lower audio frequencies which give maximum output, for at such frequencies a reasonable length of oscilloscope trace can be observed. A number of these test frequencies between 200 c/s and 500 c/s are determined by varying the frequency fed into the machine and noting those that give the greatest vertical deflection of the spot on the oscilloscope of the Test Set. Having determined the possible test frequencies the tone source is set to one of them. On depressing the "Trigger" key the tone to the artificial reverberation machine will be cut, the time base of the oscilloscope will begin its sweep and the decaying output of the machine will be observed as the vertical deflection of the trace decreases with time. Returning the "Trigger" key to its centre position restores the input tone to the machine and the oscilloscope spot to its starting position. The decay may be observed as many times as necessary and the feed-back reproducing amplifier gain adjusted until the mean envelope of the decay pattern from the machine coincides with the relevant graticule marking on the oscilloscope. This should be repeated at a number of the previously determined test frequencies between 200 c/s and 500 c/s when fair (i.e. not necessarily exact) agreement should be indicated.

4.2. Measurement of Noise.

With the "Test" switch of the Test Set in the "Noise" position the gain of the logarithmic amplifier is automatically increased 20 dB. If the tone source is disconnected and the "Trigger" key depressed the noise may now be observed, the maximum permissible level being indicated on the graticule.

4.3. Checking Erasure Efficiency.

The check consists of observing the decrease in recorded level of a signal in the medium after it has passed the erase head in successive revolutions of the wheel. This decrease is observed by monitoring the output of Head No. 7 and the "Repro. Head Mon." switch of the artificial reverberation machine is, therefore, set to Head No. 7 position and the "Rev. Time" switch to the "Mon." position. The connections between the Test Set and the machine are as described in Section 4.1. When the input to the artificial reverberation machine is cut, by depressing the "Trigger" key on the Test Set, a signal is left recorded on most of the wheel. Maximum recorded level is then observed in the first rotation past Head No. 7 and the result of one erasure in the next rotation past the head. When the erasing system is working properly the difference in these two observed levels should be at least 45 dB. If the erasing system is not working properly two or more steps of smaller difference will be observed, each step corresponding to the level remaining in the medium after successive rotations.

4.4. Checking the Nominal Frequency Response.

The graticule of the Test Set is engraved with a series of horizontal lines corresponding to various input levels to the Test Set with intervals of 10 dB. To check the frequency response of any head on the artificial reverberation machine, the Test Set is connected as described in Section 4.1. The "Repro. Head Mon." switch in the artificial reverberation machine is then set to the position which selects the reproducing head it is desired to test and the "Rev. Time" switch is set to the "Mon." position. Signals of 1 kc/s and 6 kc/s are then fed, in turn, to the recording amplifier and the relative reproduced level noted on the Test Set graticule. When the machine is properly set up, the difference between the output levels of these two frequencies should be 10 dB. Slight movements about the chosen separation between the reproducing head and track may have to be made if this 10 dB difference is not indicated. This procedure has been described in full detail in the "Notes on Adjustment, Checking and Maintenance of the Artificial Reverberation Machine" already distributed. The check may, of course, be carried out using a P.P.M. or any other suitable level indicating meter, in place of the Test Set.

5. REFERENCES.

1. Mayo, C.G. and Beadle, D.G. "Equipment for Acoustics Measurements", Parts 3 and 4, *Electronic Engineering*, Nov.-Dec. 1951.
2. Williams, F.C. "Introduction to Circuit Techniques for Radio Location", *J.I.E.E.*, 93, Part IIIA, No. 1, 1946.
3. Briggs, B.H. "The Miller Integrator", *Electronic Engineering*, XX, 243, 279, 325, 1948.